PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 040046PC	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. **PCT**/AU2005/000160	International filing date *(day/month/year)* 9 February 2005	Priority date *(day/month/year)* 9 February 2004

International Patent Classification (IPC) or national classification and IPC

Int. Cl.
F15D 1/10 (2006.01) ***B01D 51/02*** (2006.01) ***B03C 3/00*** (2006.01)
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B01D 50/00 (2006.01) ***B01F 5/06*** (2006.01)

Applicant

INDIGO TECHNOLOGIES GROUP PTY LTD et al

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 3 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. [X] *(sent to the applicant and to the International Bureau)* a total of **6** sheets, as follows:
      [X] sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      [ ] sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. [ ] *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or table related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:

[X]	Box No. I	Basis of the report
[ ]	Box No. II	Priority
[ ]	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
[ ]	Box No. IV	Lack of unity of invention
[X]	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
[ ]	Box No. VI	Certain documents cited
[ ]	Box No. VII	Certain defects in the international application
[ ]	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
6 September 2005	10 January 2006
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer **JOHN DEUIS** Telephone No. (02) 6283 2146

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/AU2005/000160

Box No. I Basis of the report

1. With regard to the **language,** this report is based on:

[X] The international application in the language in which it was filed

[ ] A translation of the international application into , which is the language of a translation furnished for the purposes of:

[ ] international search (under Rules 12.3(a) and 23.1 (b))

[ ] publication of the international application (under Rule 12.4(a))

[ ] international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

[ ] the international application as originally filed/furnished

[X] the description:

pages **1-3, 6-14** as originally filed/furnished
pages* **4-5** received by this Authority on **6 September 2005** with the letter of **6 September 2005**
pages* received by this Authority on with the letter of

[X] the claims:

pages as originally filed/furnished
pages* as amended (together with any statement) under Article 19
pages* **15-18** received by this Authority on **6 September 2005** with the letter of **6 September 2005**
pages* received by this Authority on with the letter of

[X] the drawings:

pages **1/6-6/6** as originally filed/furnished
pages* received by this Authority on with the letter of
pages* received by this Authority on with the letter of

[ ] a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. [ ] The amendments have resulted in the cancellation of:

[ ] the description, pages
[ ] the claims, Nos.
[ ] the drawings, sheets/figs
[ ] the sequence listing *(specify)*:
[ ] any table(s) related to the sequence listing *(specify)*:

4. [ ] This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

[ ] the description, pages
[ ] the claims, Nos.
[ ] the drawings, sheets/figs
[ ] the sequence listing *(specify)*:
[ ] any table(s) related to the sequence listing *(specify)*:

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/AU2005/000160

Box No. V **Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	**1-32**	**YES**
	Claims		**NO**
Inventive step (IS)	Claims	**1-32**	**YES**
	Claims		**NO**
Industrial applicability (IA)	Claims	**1-32**	**YES**
	Claims		**NO**

2. Citations and explanations (Rule 70.7)

None of the individual citations disclose all the essential features as claimed. Claims 1-32 are novel and involve an inventive step.

The invention is directed to a method and apparatus for promoting interactions between different types of particles in a fluid flow.

The features of promoting interaction between two different sized particle(s) in a fluid stream, by generating turbulent eddies designed to effect the different sized particles so that different trajectories will be followed, increasing particle collisions and interactions, were not found in any other documents that would be regarded by a person skilled in the art, as being obvious to combine with any of the citations.

The closest art found was:
D1: US 6224654 B (CHAWLA) 1 May 2001
D2: GB 2087249 A (BALCKE-DURR AKTIENGESELLSCHAFT) 26 May 1982
D3: US 5626651 A (DULLIEN) 6 May 1997
D4: US 3883324 A (BALLA et al.) 13 may 1975

Unfortunately, current design philosophies do not adequately address these criteria.

It is an aim of the present invention to provide method and apparatus for achieving improved interaction of particles in fluid flows.

It is another aim of this invention to provide a method of custom designing a formation to generate particle scale turbulence to cause interactions between particular types of particles in a fluid flow in a highly efficient manner.

SUMMARY OF THE INVENTION

This invention is based on the recognition that two particles of different mass and/or aerodynamic properties in a flowing fluid will respond differently to a turbulence eddy of a predetermined size in the fluid flow. More specifically, if the eddy is of a particular scale, the different particles will be entrained in the eddy to different extents, and will therefore follow different trajectories. Consequently, the likelihood of collision or interaction between the particles is increased.

Particles of similar mass and/or aerodynamic properties which are captured by, and entrained in, a turbulent eddy will follow roughly the same path and consequently do not impact with each other to any significant extent. A particle of larger mass and/or different aerodynamic property will not be entrained into the eddy, or will be entrained to a substantially lesser extent, and will therefore travel through the eddy on a different trajectory and be impacted by many more other particles entrained into the same eddy.

To improve the likelihood of collisions between two types of particles in a fluid flow, e.g. to promote their agglomeration or the adsorption of the smaller particle by the larger particle, a formation is designed to generate turbulence of such scale that different particles are entrained to significantly different extents.

In one broad form, the present invention provides a method of promoting interaction between at least two types of particles in a fluid stream, comprising the step of generating turbulent eddies in the fluid stream to cause interactions between the two types of particles in the turbulent eddies, characterised in that the eddies are of such size and/or intensity that the two types of particles are entrained in the eddies to significantly different extents.

In another form, the invention provides apparatus for promoting interaction between at least two types of particles in a fluid stream, comprising means

for generating turbulent eddies in the fluid stream to cause interactions between the two types of particles in the turbulent eddies, characterised in that the eddies are of such size and/or intensity that the two types of particles are entrained in the eddies to significantly different extents.

Preferably, the turbulent eddies are of such size and/or intensity that one type of particle is substantially fully entrained while the other type of particle is not substantially entrained, to thereby maximize relative slip and the likelihood of interactions between the two type of particles.

In yet another broad form, the invention provides a method of custom designing a formation for generating turbulent eddies in a fluid stream to promote interaction between at least two types of particles in the turbulent eddies, comprising the steps of:

(i) identifying relevant characteristics of the two types of particles,

(ii) performing a Stokes Number analysis to determine the optimal characteristic eddy size to cause one type of particle to have a significantly higher slip velocity than the other type of particle, and

(iii) designing a formation to generate eddies in the fluid stream having the optimal size determined in step (ii) above.

The relevant characteristics of the two types of particles normally include the size and density of the particles.

The determination of the optimal characteristic eddy size may involve an iteration process.

As the standard equation for Stokes Number assumes that particles are spherical, an empirical "shape factor" may be applied to account for the shape of the particles.

For two given types of particles, e.g. a collector particle and a collected particle, the invention provides a method of custom designing a formation to generate turbulent eddies of such size and scale as to maximise the differential slip velocities of the two particles and thereby maximise the likelihood of interactions between the particles. Preferably, the eddies in the generated turbulence will be of such size that the slip velocity of the collector particle is maximised, while the slip velocity of the collected particle is minimised.

Throughout this specification where the context permits, the term

CLAIMS

1. A method of designing a formation of vortex generators for generating turbulent eddies in a fluid stream to promote interaction between at least two types of particles in the turbulent eddies, comprising the steps of:
(i) identifying relevant characteristics of the two types of particles,
(ii) performing a Stokes Number analysis to determine the optimal characteristic eddy size to cause one type of particle to have a significantly higher slip velocity than the other type of particle, and
(iii) designing a formation to generate eddies in the fluid stream having the optimal size determined in step (ii) above.

2. A method as claimed in claim 1, wherein the relevant characteristics of the two types of particles include the size and density of the particles.

3. A method as claimed in claim 1, wherein the determination of the optimal characteristic eddy size involves an iteration process.

4. A method as claimed in claim 1, wherein the Stokes number for one type of particle is at least an order of magnitude greater than that of the other type of particle.

5. A method as claimed in claim 4, wherein at least one of the particles has a Stokes number in the range 10^{-2} to 10^{2}.

6. A method as claimed in claim 1, wherein the optimal characteristic eddy size is one at which the difference in the Stokes Numbers of the two types of particles is maximised.

7. A method as claimed in claim 1, wherein the formation is designed to comprise a plurality of vanes.

8. A method of promoting interaction between at least two types of particles in

a fluid stream, comprising the step of generating turbulent eddies in the fluid stream to cause interactions between the two types of particles in the turbulent eddies, characterised in that the eddies are of such size and/or intensity that the two types of particles are entrained into the eddies to significantly different extents.

9. A method as claimed in claim 8, wherein the eddies are of such size and/or intensity that one type of particle is substantially fully entrained while the other type of particle is not substantially entrained, to thereby maximize relative slip and the likelihood of interactions between the two types of particles in the eddies.

10. A method as claimed in claim 8, wherein the Stokes number for one type of particle is at least an order of magnitude greater than that of the other type of particle.

11. A method as claimed in claim 10, wherein the Stokes number for at least one of the particles is in the range 10^{-2} to 10^{2}.

12. Apparatus for promoting interaction between at least two types of particles in a fluid stream, comprising means for generating turbulent eddies in the fluid stream to cause interactions between the two types of particles in the turbulent eddies, characterised in that the eddies are of such size and/or intensity that the two types of particles are entrained into the eddies to significantly different extents.

13. Apparatus as claimed in claim 12, wherein the eddies are of such size and/or intensity that one type of particle is substantially fully entrained while the other type of particle is not substantially entrained, to thereby maximize relative slip and the likelihood of interactions between the two types of particles in the eddies.

14. Apparatus as claimed in claim 12, wherein the Stokes number for one type of particle is at least an order of magnitude greater than that of the other type of particle.

15. Apparatus as claimed in claim 14, wherein the Stokes number for at least one of the particles is in the range 10^{-2} to 10^{2}.

16. A formation to generate eddies in a fluid stream, the formation being designed by the method of claim 1.

17. A method as claimed in claim 1, wherein one type of particle is solid, liquid or gaseous, and the other type of particle is solid, liquid or gaseous.

18. A method as claimed in claim 8, wherein one type of particle is solid, liquid or gaseous, and the other type of particle is solid, liquid or gaseous.

19 A method as claimed in claim 8, wherein the fluid stream is in a duct and the step of generating turbulent eddies comprises placing a plurality of vane members in spaced relationship across the duct to generate a multiplicity of eddies.

20. A method as claimed in claim 19, wherein the spacing between the vane members is of the order of the width of the vane members.

21. A method as claimed in claim 19, further comprising the step of placing additional rows of spaced vane members across the duct to form an array of vane members, the additional rows being spaced longitudinally along the duct.

22. A method as claimed in claim 21, wherein the longitudinal spacing between the additional rows is of the order 1 to 3 times the width of the vane members.

23. A method as claimed in claim 19, wherein there are sufficient additional rows of spaced vane members spaced longitudinally along the duct such that time taken for the fluid stream to pass the array is at least 0.1 seconds.

24. Apparatus as claimed in claim 12, wherein one type of particle is solid, liquid or gaseous, and the other type of particle is solid, liquid or gaseous.

25. Apparatus as claimed in claim 12, wherein the fluid stream is in a duct and

the means for generating turbulent eddies comprises a plurality of vane members in spaced relationship across the duct to generate a multiplicity of eddies.

26 Apparatus as claimed in claim 25, wherein the spacing between the vane members is of the order of the width of the vane members.

27. Apparatus as claimed in claim 25, further comprising additional rows of spaced vane members across the duct to form an array of vane members, the additional rows being spaced longitudinally along the duct.

28. Apparatus as claimed in claim 27, wherein the longitudinal spacing between the additional rows is of the order 1 to 3 times the width of the vane members.

29. Apparatus as claimed in claim 25, wherein each vane member is of Z-shaped cross-section.

30. Apparatus as claimed in claim 29, wherein each vane member has spaced tooth portions along its longitudinal edges.

31. Apparatus for causing interaction between large particles and fine particles in a fluid stream, comprising an array of micro-vortex generating formations for generating a multiplicity of micro-vortices across the fluid stream, the array including a plurality of longitudinally spaced rows of micro-vortex generating formations, each row having a plurality of transversely spaced micro-vortex generating formations, and wherein the fine particles are substantially entrained in the micro-vortices while the large particles are not substantially entrained, to thereby maximize relative slip and the likelihood of interactions between the two types of particles.

32. Apparatus as claimed in claim 31, each micro-vortex generating formation is a vane member of Z-shaped cross-section with scalloped longitudinal edges.